IMPROVED FLASHLIGHT

PRIORITY

This application claims priority to U.S. Application Serial No. 09/013,078 filed January 26, 1998 and entitled, "Improved Flashlight", which is incorporated herein by reference.

FIELD OF INVENTION

The present invention relates to the field of flashlights and more specifically to hand held portable battery operated flashlights.

BACKGROUND OF THE INVENTION

Flashlights generally include a battery chamber having an end cap for retaining one or more batteries, a light bulb electrically connected to the one or more batteries and a reflector for reflecting light from the light bulb in a particular direction. The electrical connection between the batteries and the light bulb usually includes a switch mechanism for selectively providing electrical energy from the batteries to the light bulb and, therefore enabling the flashlight to be turned on and off. The primary function of flashlights is to provide a convenient portable storable light source which is capable of projecting light in a particular direction.

Some flashlights are capable of focusing and defocusing light projected by the flashlight by allowing the light bulb to be moved within the reflector along the reflector's optical axis. The reflector is typically a parabolic shaped reflector because such a reflector provides a theoretical focus of the light when the light bulb is positioned at the parabolic reflector's focal point. In this regard, light rays emanating from a light bulb positioned at the focal point of a parabolic reflector are reflected parallel to the parabolic reflector's optical axis. Referring to Fig. 1A, a light beam dispersion is shown from a parabolic reflector with a light bulb positioned at the focal point of the parabolic reflector. In contrast, as shown in Fig. 1B, when the light bulb is moved away from the parabolic reflector's focal point, light rays reflected by the parabolic

reflector diverge (i.e., defocus) leaving a glaring light void about the center of the reflected light rays and decreasing the light gathered from the light bulb.

The electrical energy to enable a flashlight to operate is usually provided by one battery, or two or more batteries in series arrangement, held within the battery chamber of the flashlight. When the charge in the batteries is depleted, a user will typically replace the batteries by removing the end cap, removing the old batteries from the battery chamber, inserting new batteries into the battery chamber, and replacing the end cap. However, when replacing multiple batteries in a flashlight, the possibility arises that a user may improperly position the batteries in a nonseries arrangement. For example, a user may improperly align the new batteries such that the positive poles of the batteries face each other, or may comingle the old batteries with the new batteries and misalign a new battery with an old battery. Misaligning the batteries may have undesired consequences, for example explosion causing physical injury, to a user of the flashlight.

Additionally, batteries often naturally emit hydrogen gas. As such, when batteries are contained within the flashlight's battery chamber, the possibility arises that hydrogen gas emitted by the batteries may become trapped within the flashlight. In some circumstances, a defective battery will emit high quantities of hydrogen gas. As a consequence, hydrogen gas may accumulate within the flashlight, thus raising the possibility of undesired consequences to a user of the flashlight, for example explosion causing physical injury.

Finally, parts of the flashlight sometimes require replacement. For example, the flashlight's light bulb will require replacement when the light bulb's filament burns out, which is often discovered when the flashlight is needed (e.g., when there are no other sources of light, including for example electrical power outages which occur at night or darkness when camping

outdoors). Flashlights usually include a spare light bulb positioned on the interior of the end cap. Replacing a burned out bulb with a bulb positioned on the end cap is difficult, especially in low or no light conditions. For example, during a power outage, replacing the light bulb in a typical flashlight would require a user to remove the end cap, locate and grasp a small spare light bulb on the end cap without allowing the batteries to fall out of the flashlight, replace the end cap, remove the head assembly, replace the burned out bulb and replace the head assembly, all in darkness.

SUMMARY OF THE INVENTION

It is an objective of the present invention to provide an improved flashlight which maximizes the light gathered from a light bulb, optimumly focuses the gathered light into a projected light beam and minimizes the light void within the light beam throughout the range of focus.

It is an further objective of the present invention to provided an improved flashlight having improved switching and focusing capabilities.

In accordance with one embodiment of the present invention, an improved flashlight is provided having an end cap, chamber, head assembly and lamp holder assembly. In one embodiment of the invention, the head assembly includes an elliptical reflector to increase the amount of light reflected by the flashlight when a light source is positioned within the elliptical reflector. Preferably, the elliptical reflector has an eccentricity value of no less than about .80 and no more than about .99. Preferably, the elliptical reflector has a vertex curvature value of no less than about 2.0 and no more than about 5.2. In one arrangement, the elliptical reflector has an eccentricity value of about .96 and a vertex curvature of about 3.1.

In accordance with another embodiment of the present invention, a flashlight having an elliptical reflector is matched with either a negative or concave lens, or a flat or planar lens. In this regard, the focusing and light gathering characteristics of the flashlight are optimized when the flashlight's elliptical reflector is matched with a negative or flat lens. Preferably, the flashlight's elliptical reflector is matched with a lens having an effective focal length no less than about -2.5" and no more than about 0" (i.e., a planar or flat lens). In one arrangement, an elliptical reflector having an eccentricity value of about .96 and a vertex curvature of about 3.1 is matched with a lens having an effective focal length of about 0".

In accordance with another embodiment of the present invention, the head assembly includes a hyperbolic reflector to increase the amount of light reflected by flashlight when a light source is positioned within the reflector. Preferably, the hyperbolic reflector has an eccentricity value of no less than about 1.01 and no more than about 1.25. Preferably, the hyperbolic reflector has a vertex curvature value of no less than about 2.0 and no more than about 7.0. In one arrangement, the hyperbolic reflector has an eccentricity value of about 1.04 and a vertex curvature of about 3.3.

In accordance with another embodiment of the present invention, a flashlight having a hyperbolic reflector is matched with either a positive or convex lens, or a flat or planar lens. In this regard, the focusing and light gathering characteristics of the flashlight are increased when the flashlight's hyperbolic reflector is matched with a positive or flat lens. Preferably, the hyperbolic reflector is matched with a lens having an effective focal length no less than about 0" and no greater than 2.5". In one arrangement, a hyperbolic reflector having an eccentricity value of about 1.04 and a vertex curvature of about 3.3 is matched with a lens having an effective focal length of about 0".

It is another objective of the present invention to provide a flashlight with an improved electrical connection between the batteries and the light source. In accordance with another embodiment of the present invention, the flashlight includes electrode connections which substantially reduce the likelihood that electrical energy will be conducted from batteries which are improperly aligned within the flashlight. In this regard, the electrode connection intended to contact the negative pole of the battery includes a non-conductive portion at the center of the electrode connection and a conductive portion at the perimeter of the electrode connection. As such, in the circumstance wherein a battery is inserted into the flashlight with the positive pole facing the electrode connection, the positive pole will only contact the non-conductive portion, and not the conductive portion, of the electrode connection. Additionally, the electrode connection intended to contact the positive pole of the battery includes a conductive spring having a nonconductive coating. As such, in the circumstance wherein a battery is inserted into the flashlight with the negative pole facing the electrode connection, the negative pole only will contact the nonconductive coated portion.

It is another objective of the present invention to provide a flashlight with a light holder assembly that facilitates lamp bulb replacement. In one embodiment of the present invention, the lamp holder assembly includes a lamp socket having a lamp guide which provides a guide for installing lamp bulbs into the lamp socket and also provides a secure position for the lamp bulb. In accordance with one embodiment of the present invention, the guide facilitates replacing lamps in less than desirable light conditions, as well as protects the lamp from receiving impact shocks when the flashlight is jarred.

It is another objective of the present invention to provide a flashlight capable of maintaining a spare lamp bulb in close proximity to the flashlight's light bulb thus providing for

the efficient and easy replacement of the lamp bulb when needed. In accordance with one embodiment of the present invention, the flashlight includes a lamp holder assembly which includes a notch for receiving and holding a spare lamp. As such, a spare lamp is easily accessible by simply removing the head assembly from the chamber and all that is required to replace the lamp bulb, is removal of the lamp bulb in the lamp socket, removing the spare lamp, and inserting the spare lamp into the lamp socket. Preferably, the lamp holder assembly further includes a fluorescent coating or additive which illuminates light in otherwise dark conditions, thereby facilitating lamp bulb replacement in less than desirable light conditions.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1A shows a light beam dispersion from a parabolic reflector with a light source positioned at the focal point of the reflector.

Fig. 1B shows a light beam dispersion from a parabolic reflector with a light source defocused 1/3 the distance from the focal point to apex of the reflector curvature.

Fig. 2 is a perspective view of a flashlight in accordance with the present invention.

Fig. 3 is an exploded perspective view illustrating the assembly of the flashlight of Fig. 2.

Fig. 4 is an exploded side view of the end cap, chamber, lamp holder assembly and head assembly.

Fig. 5 is a cross-section view of the flashlight down the center of the flashlight of Fig. 2 as taken through the plane indicated by 2-2.

Fig. 6A is an exploded perspective view of the interior of the end cap.

Fig. 6B is a cross-section view of the end cap through the plane indicated by 2-2.

Fig. 7A is an exploded perspective view of the head assembly.

Fig. 7B is a partial cross-section of the head assembly of Fig. 7A as taken through the plane indicated by 7-7.

Fig. 8A is an exploded view of the lamp holder assembly.

Fig. 8B is a partial cross-section of the lamp holder assembly of Fig. 8A as taken through the plane indicated by 8-8.

Figs. 9A and 9B are cross-section views of the flashlight of Fig. 2 as taken through the plane indicated by 2-2 showing aligned and misaligned batteries, respectively.

Fig. 10 is a perspective view of the lamp holder assembly positioned within the chamber.

Fig. 11 is partial cross-section of the head portion of the flashlight of Fig. 2, as taken through the plane indicated by 2-2, showing the flashlight in the "off" position.

Fig. 12 is partial cross-section of the head portion of the flashlight of Fig. 2, as taken through the plane indicated by 2-2, showing the flashlight in the "on" position.

Fig. 13A and 13B show the results of simulations for a variety of eccentricity values.

Fig. 14A shows the lamp prior to being inserted into the lamp socket.

Fig. 14B shows the lamp inserted into the lamp socket.

Fig. 14C shows a spare lamp removed from the notch which holds the spare lamp.

Fig. 15A is a front view of the lamp holder assembly when the head assembly is removed from the chamber.

Fig. 15B is a front view of the lamp holder assembly when the head assembly is attached to the chamber.

DETAILED DESCRIPTION

Referring to Figs. 2 through 5, a flashlight 10 in accordance with one embodiment of the present invention is shown having a chamber 20, end cap 30, head assembly 40 and lamp holder assembly 50. The chamber 20 includes an interior portion for holding two batteries 60, 62 in a series arrangement, openings at a first end 210 and a second end 220, a first o-ring 230 positioned at the first end 210, and a second o-ring 240 positioned at the second end 220. Referring additionally to Figs. 6A and 6B, the end cap 30 includes a bowed tripod portion 310 to facilitate standing the flashlight 10 on a flat surface, interior threads 320 and a conductive disk 330. Referring additionally to Figs. 7A and 7B, the head assembly 40 includes a head piece 410, a first o-ring 420, a bezel 430, a reflector 440, a second o-ring 450 and a lens 460. The head piece 410 includes a first end 411, a circular tab 412 located within the head piece 410 at the first end 411, guides 413, a second end 414 and lugs 415 located within the head piece 410 at the second end 414. The reflector 440 includes a reflective surface on the reflector's 440 interior, a first central opening 442, a second central opening 444 substantially opposite the first central opening 442, wings 446, and outer threads 448. Preferably, the reflector 440 consists of a durable synthetic material, such as that offered by General Electric Company under the name ULTEM. The bezel 430 includes a first end 431, inner threads 432 at the first end 431 which thread to the reflector's 440 outer threads 448, a recessed circular tab 433 at the first end 431, a second end 434, and a circular tab 435 at the second end 434. The lens 460 is positioned at the perimeter of the first end 431 of the bezel 430. Referring additionally to Figs. 8A and 8B, the lamp holder assembly 50 includes a lamp holder 510, a conductive spring 520, a switch lever 530, a second lever 540, a switch spring 550, a switch contact 560, a second spring 570, a spring holder 580, a conductive strip 590 and a strip support 592. The spring holder 580 includes a

spring tab 582, first tab 584, second tab 586, and a first conductive contact 588. Preferably, the spring holder 580 includes a notch 589 wherein a hydrogen catalyst can be placed to absorb hydrogen gas emitted by the batteries 60, 62. The exterior of the flashlight 10 consists of a metal or durable synthetic material. For example, the exterior of the flashlight 10 can consist of a polycarbonite, such as acrylonitrile-butadiene-styrene, or the polycarbonite offered by General Electric Company under the name CYCOLAR.

The chamber 20, which is shown in Fig. 5 holding two batteries 60, 62, is enclosed at the first end 210 by the end cap 30 and at the second end 220 by the head assembly 40. Referring to Figs. 4-8, the end cap 30 is removably attached to the chamber 20 at the first end 210 to selectively uncover the interior portion of the chamber 20 for inserting or removing the batteries 60, 62. In this regard, the chamber 20 includes threading 250 on the exterior surface at the first end 210 of the chamber 20 for engaging the interior threads 320 on the end cap 30. The first o-ring 230 provides a snug attachment when the end cap 30 is threaded to the chamber 20.

When assembled to the chamber 20, the lamp holder assembly 50 is positioned inside the chamber 20 at the second end 220. As shown in Fig. 10, when assembled to the chamber 20, the lamp holder assembly 50 does not extend beyond the second end 220 of the chamber 20. Referring to Figs. 3, 4, 8A, 8B and 10, the lamp holder assembly 50 is assembled to the chamber 20 by first attaching the conductive spring 520 to the spring holder 580. The spring holder 580 includes a spring tab 582 which engages and retains a portion of the conductive spring 520. The spring holder 580 and conductive spring 520 are next attached to the second end 220 of the chamber 20. In this regard, the spring holder 580 includes a first tab 584 and a second tab 586 for engaging the second end 220 of the chamber 20. The chamber 20 includes an end guide 260,

and the end guide 260 includes a first recessed tab 262 for engaging the first tab 584, and a second recessed tab 263, for engaging the second tab 586. Referencing Fig. 10, attachment of the spring holder 580 and conductive spring 520 to the second end 220 occurs by inserting the spring holder 580 and attached spring 520 in the first end 22 of the chamber 20 and moving the spring holder 580 toward the second end 220 of the chamber 20 until the first recessed tab 262 engages the first tab 584 and the second recessed tab 263 engages the second tab 586.

The lamp holder 510, with the switch lever 530 and second lever 540 assembled on the lamp holder 510, is next inserted into the second end 220 of the chamber 20. The lamp holder 510 includes tabs 511, a switch slot 512 and a second slot 513. The switch lever 530 includes tabs 532 and slots 534, and the second lever 540 includes tabs 542 and slots 544. The switch lever's 530 slots 534 mate with the switch slot 512 to allow the switch lever 530 to slide along the switch slot 512. The second lever's 540 slots 544 mate with the second slot 513 to allow the second lever 540 to slide along the second slot 513. Referencing Figs. 3, 5, 8A, 8B and 10, the lamp holder 510 is next partially inserted into the second end 220 of the chamber 20 by aligning the switch slot 512 with the first slotted opening 264 of the end guide 260, and the second slot 513 with the second slotted opening 266 of the end guide 260. Once partially inserted, the switch lever 530 and second lever 540 are spring loaded onto the lamp holder 510 by inserting the switch spring 550 and second spring 570, and aligning and engaging the switch lever's 530 slots 534 with the switch slot 512 and aligning and engaging the second lever's 540 slots 544 with the second slot 513. With the switch lever 540 and second lever 550 depressed, the lamp holder 510 is fully seated into the second end 220 of the chamber 20. As a result, as shown in Fig. 10, the switch lever's 530 tabs 532 and the second lever's 540 tabs 542 engage the chamber 20 at points 514. As shown in Fig. 5, the lamp holder's 510 tabs 511 engage the interior of the

chamber 20. Referencing Fig. 3, 8A and 10, the switch slot 512 engages the recessed tab 265 of the end guide 260 and the second slot 513 engages the recessed tab 267 of the end guide 260. Preferably, the lamp holder assembly 510 snap fits to the chamber 20. Referencing Fig. 11, the lamp holder 510 encloses the spring tab 582, further securing the conductive spring 520 to the spring holder 580. Referencing Fig. 11, the spring holder 580 does not contact the interior of the chamber 20. Referencing Fig. 10, the lamp 70 extends from the second end 220 of the chamber 20 when the lamp 70 is installed into the lamp holder assembly 50.

Referring to Figs. 7A and 7B, the head assembly 40 is assembled by first inserting the reflector 440 into first end 431 of the bezel 430 and threading the reflector's 440 threads 448 to the bezel's 430 inner threads 432. The second o-ring 450 is next inserted into the circular recessed tab 433 and the lens 460 is fixedly attached to the bezel 430 by pressing the lens 460 into the circular recessed tab 433. The o-ring 450 allows for secure attachment between the lens 460 and the bezel 430. Preferably, the lens 460 snap fits to the bezel 430. The first o-ring 420 is next placed over the circular tab 435 at the second end 434 of the bezel 430, and the second end 434 of the bezel 430 is inserted into first end 411 of the head piece 410 with the wings 446 of the reflector 440 aligned with the guides 413 of the head piece 410. When the second end 434 of the bezel 430 is fully inserted into the first end 411 of the head piece 410, the bezel's 430 circular tab 434 engages the head piece's 410 circular tab 412, and the wings 446 of the reflector 440 engage the guides 413 of the head piece 410. As a result, the bezel 430 is only allowed to rotate relative to the head piece 410 (i.e., radially) and cannot move away from the head piece 410 (i.e., axially). Preferably, the bezel 430 snap fits to the head piece 410. As a result of the wings 446 of the reflector 440 engaging the guides 413 of the head piece 410, the reflector 440 moves within the bezel 430 axially when the bezel 430 is moved radially.

The head portion of the flashlight 10 is assembled by attaching the assembled head assembly 40 to the chamber 20, having the lamp holder assembly 50 assembled in the chamber 20, such that the lamp 70 is positioned within the first central opening 442 of the reflector 440. In this regard, the head assembly 40 is removably attached to the chamber 20 at the second end 220. Figs. 10 and 15A show the lamp holder assembly 50 assembled in the chamber 20 when the head assembly is removed from the chamber 20. The chamber 20 includes the end guide 260 formed on the exterior surface at the second end 220 of the chamber 20. Referencing Figs. 3 and 10, the end guide 260 includes paths 261 which engage the lugs 415 on the head piece 410. The lugs 415 are aligned with paths 261, and the head assembly 40 is guided in the direction 287 until the head assembly 40 is fully seated on the second end 24 of the chamber 20. The head assembly 40 is then rotated in the direction 288 to a first detent, which is caused by the switch lever 530 being positioned between two of the guides 413. The flashlight 10 is in the "off" position at this position. In this position, the head assembly 40 is only permitted to rotate relative to the chamber 20 (i.e., radially) and cannot move away from the chamber 20 (i.e., axially). The second o-ring 240 provides a secure attachment between the head assembly 40 and the chamber 20.

When fully assembled and holding batteries 60, 62 in proper alignment, the flashlight 10 is capable of selectively electrically coupling the lamp 70 to the batteries 60, 62. The chamber 20 includes a conductive strip 590 along the length of the chamber 20, between the first end 210 and the second end 220. The conductive strip 590 is supported at the first end 210 of the chamber 20 by the strip support 592. Referring to Figs. 6A and 6B, the end cap 30 includes a nonconductive area 340. Referencing Fig. 8, when the end cap 30 is attached to the chamber 20, the conductive disk 330 is electrically connected to the conductive strip 590 at

point 593. The conductive disk 330 electrically connects the negative contact of the battery 60 to the conductive strip 590 when the battery 60 is properly aligned in the chamber 20 as shown in Fig. 9A. The nonconductive area 340 prevents electrical connection when the battery 60 is improperly aligned in the chamber 20 as shown in Fig. 9B. In this regard, the positive contact of an improperly aligned battery 60 only contacts the nonconductive area 340 and does not contact the conductive disk 330, due to the opening 331, as shown in Fig. 6A.

The lamp holder assembly 50 selectively electrically connects the lamp 70 to properly positioned batteries 60, 62 in accordance with the axial movement of the head assembly 40. Referencing Fig. 11, the flashlight 10 is shown in the "off" position. Referencing Figs. 3, 10 and 12, the flashlight 10 is moved to the "on" position by rotating the head assembly 40 in the direction 288. The head portion of the flashlight 10 can be disassembled by rotating the head assembly 40 from the "off" position in a direction opposite 288 and disengaging the head assembly 40 from the chamber 20 along paths 261.

Referring to Figs. 8-12, 14A, 14B, 14C and 15, the 510 includes a lamp socket 515 for holding a lamp 70 having a first pin 72 and second pin 74 and a lamp guide 516. When the head portion of the flashlight 10 is assembled, the lamp guide 516 does not contact the reflector 440. In this regard, the reflector 440 is prevented from contacting the lamp guide 516 by stop 436 as shown in Fig. 11. The lamp guide 516 is a guide which facilitates aligning the first pin 72 and second pin 74 of the lamp 70 with the lamp socket 515 when the lamp 70 is being installed. The lamp guide 516 also provides a secure position for the lamp 70 by supporting a part of the outer portion of the lamp 70 when the lamp 70 is installed. As such, the lamp guide 516 facilitates replacing a lamp 70 in less than desirable light conditions, as well as protects the lamp 70 from receiving impact shocks from the reflector 440 when the flashlight 10 is jarred.

Additionally, the lamp holder 510 is capable of receiving and holding a spare lamp 71. In this regard, the lamp holder 510 includes a notch 517 which is capable of receiving a spare lamp 71.

As shown in Fig. 15B, the spare lamp 71 in the notch 517 is covered by the switch lever's 530 tab 532 when the head portion of the flashlight 10 is assembled. As shown in Fig. 15A, the spare lamp 71 in the notch 517 becomes uncovered by the switch lever's 530 tab 532 when the head assembly 40 is disassembled from the chamber 20. As such, as shown in Figs. 10, 14A, 14B, 14C, 15A and 15B, the spare lamp 71 is easily accessible by removing the head assembly 40 from the chamber 20, thereby making the spare lamp 71 held by the lamp holder 510 accessible. In this regard, all that is required to replace the lamp 70, is removal of the lamp 70 from the lamp socket 515, removing the spare lamp 71 from the notch 517, and installing the spare lamp 71 into the lamp socket 52. Preferably, the insulated lamp holder 510 includes a phosphorescent coating or additive, which illuminates light in otherwise dark conditions, thereby facilitating lamp replacement in less than desirable light conditions.

Referencing Figs. 8A, 8B, 9A and 9B, the first pin 72 is electrically connected to the switch spring 550 by conductive contact 551, and the second pin 74 is electrically connected to the spring 520 by the first conductive contact 588, when the lamp 70 is positioned in lamp holder assembly 50. The conductive spring 520 includes an portion 521 having a nonconductive coating and a tail 522. As shown in Fig. 9A, the tail 522 contacts the positive pole of the battery 62 when the battery 62 is properly aligned in the chamber 20. As shown in Fig. 9B, the portion 521 having a nonconductive coating prevents electrical contact with an improperly aligned battery 62. In this regard, the negative pole of an improperly aligned battery 62 only contacts a nonconductive portion of conductive spring 520 and does not contact a conductive portion,

thereby preventing electrical connection and removing the possibility of a catastrophic event due to reverse polarization.

Referring to Figs. 5, 8A, 8B, 11 and 12, the switch lever 530 is moveable between the "on" and "off" positions when the head portion of the flashlight 10 is assembled. The switch lever 530 includes a switch contact 560 having an edge 561. The switch contact 560 is electrically connected to the switch spring 550. Referencing Fig. 11, the flashlight 10 is shown in the "off" position. In this position, the switch lever 530 is fully extended due to the switch lever 530 being position between two of the guides 413 within the head piece 410. As a consequence, the switch lever 530 does not electrically connect the edge 561 to the to the conductive strip 590 at point 594. Moreover, the switch lever 520 in fully extended position provides a detent to maintain the flashlight 10 in the "off" position until flashlight 10 is moved to the "on" position. Referencing Fig. 12, the flashlight 10 is in the "on" position. In this position, the switch lever 530 is compressed due to the switch lever 530 contacting one of the guides 413 within the head piece 410. As a consequence, the switch lever 530 electrically connects the edge 561 to the conductive strip 590 at point 594. In the "on" position, the second lever 540 is positioned between two of the guides 413 within the head piece 410. In this regard, as the head assembly is turned in the direction 288 from the "off" position, the second lever 540 will no longer contact one of the guides 413, and will become fully extended due to the second lever 540 being position between two of the guides 413 within the head piece 410. The second lever 540 becoming fully extended provides a detent to maintain the flashlight 10 in the "on" position until flashlight 10 is moved to the "off" position. Preferably, the head assembly 40 is rotatable about thirty degrees between the "off" and "on" positions.

The movement of the lamp 70 within the reflector 440 to focus and defocus the light emanating from the lamp 70 is independent from the radial movement of the head assembly 40 to turn the flashlight 10 "on" or "off." When assembled, as shown in Figs. 11 and 12, the lamp 70 is positioned within the interior of the reflector 440 through the first central opening 442 of the reflector 440. As such, rotating the bezel 430 relative to the head piece 410 causes the reflector 440 to move within the bezel 430 axially relative to the head piece 410. As a result, the reflector 440 moves relative to the lamp 70, and such movement allows for the light emanating from the lamp 70 to be focused by positioning the lamp 70 at the reflector's 440 focal point, or defocused by positioning the lamp 70 away from the reflector's 440 focal point.

Notably, the reflector 440 and lens 460 combination accomplishes one of the objectives of the present invention, namely to provide improved light gathering from the lamp 70, optimum focus spot and minimal light void within the light projected by the reflector 440 throughout the range of the lamp's 70 movement within interior of the reflector 440. In this regard, one embodiment of the present invention uses conic reflectors 440 other than a parabolic reflector.

The vertex curvature (i.e., the actual shape) of the reflector 440 is determined using the following equation for a Vertex Cartesian coordinate system:

$$f(r) = \mathbf{C}r^2/(1 + \sqrt{(1-\mathbf{SC}^2r^2)}), \qquad (1.1)$$

wherein C is the vertex curvature, r is the radial distance from the cylindrical center of the optic, and S is equal to unity minus the square of the eccentricity. In this regard, it was discovered that the use of nonparabolic reflectors minimized the light void which is apparent when a parabolic reflector was used, as shown in Fig. 1B. Additionally, it was also discovered that matching nonparabolic reflectors with an appropriate lens curvature optimized the direction of the rays emanating from the nonparabolic reflector. For elliptical reflectors (i.e., 0 < eccentricity < 1),

it was determined that the use of a negative or a flat lens caused a more uniform and intense ray pattern when the light source was placed at the optimum optical focal point. For hyperbolic reflectors (i.e., eccentricity > 1), it was determined that the use of a positive or flat lens caused a more uniform and intense ray pattern when the light source was placed at the optimum optical focal point.

Referring to the table shown in Figs. 13A and 13B, a series of simulations were run using the equation 1.1, wherein the eccentricity ranged from 0.8 to 1.25. The criteria for the results shown in Figs. 13A and 13B were as follows: (i) a reflector aperture (i.e., the size of the reflector's 44 second central opening 49) of 1.4375"; (ii) a reflector opening (i.e., the size of the reflector's 44 first central opening 48) of 0.19"; (iii) a maximum lighted spot size of 29" to be illuminated by the flashlight 10 at a distance of 120"; (iv) a minimum light void through out the range of focus (i.e. the movement of the lamp 70 along the reflector's 440 optical axis from about the reflector's 440 focal point to the point the lamp 70 exits the reflector 440 at either the first central opening 442 for a elliptical reflector or the second central opening 444 for a hyperbolic reflector); (v) a maximum range of motion of the lamp 70 throughout the range of focus of no greater than about .25"; (vi) a minimum angle of subtended light gathered by the reflector of about 100 degrees; and (vii) a lens with effective focal length of no less than about -2.5".

For each given eccentricity and lens combination, the vertex curvature was adjusted to attain the minimum focused spot size and void throughout the range of focus and the maximum subtended angle of light gathered by the reflector 440. This was performed for each value of eccentricity by taking a sample of lenses with effective focal lengths of no less than about -2.5", running simulations wherein the vertex curvature was increased until no void appeared when

the lamp 70 was completely defocused (i.e. the lamp 70 exits the reflector 440 at either the first central opening 442 for a elliptical reflector, or the second central opening 444 for a hyperbolic reflector). The value of vertex curvature was not increased beyond what which was reasonably necessary to remove the void, because increasing the vertex curvature further reduced the potential magnification of the lamp's 70 light beam as the lamp 70 was moved away from the focal point of the reflector 440.

In view of the simulations and the criteria specified, the elliptical reflector, preferably has an eccentricity value of no less than about .80 and no more than about .99. Preferably, the elliptical reflector has a vertex curvature value of no less than about 2.0 and no more than about 5.2. In one arrangement, the elliptical reflector has an eccentricity value of about .96 and a vertex curvature of about 3.1. In one embodiment of the present invention, a flashlight 10 having an elliptical reflector is matched with a negative or flat lens. Preferably, an elliptical reflector is matched with a lens having an effective focal length of no less than about -2.5" and no more than about 0". In one arrangement, an elliptical reflector 44 having an eccentricity value of about .96 and a vertex curvature of about 3.1 is matched with a lens 45 having an effective focal length of about 0".

In accordance with another embodiment of the present invention, the head assembly 40 includes a hyperbolic reflector. Preferably, the hyperbolic reflector has an eccentricity value of no less than about 1.01 and no more than about 1.25. Preferably, the hyperbolic reflector has a vertex curvature value of no less than about 2.0 and no more than about 7.2. In one arrangement, the hyperbolic reflector has an eccentricity value of about 1.04 and a vertex curvature of about 3.3. In another embodiment, a flashlight 10 having a hyperbolic reflector is matched with a positive or flat lens. Preferably, a hyperbolic reflector is matched with a lens

having an effective focal length no less than about 0" and no greater than about 2.5". In one arrangement, a hyperbolic reflector 440 having an eccentricity value of about 1.04 and a vertex curvature of about 3.3 is matched with a lens 460 having an effective focal length of about 0".

The foregoing description of the present invention has been presented for purposes of illustration and description. The description is not intended to limit the invention to the form disclosed herein. Consequently, the invention and modifications commensurate with the above teachings and skill and knowledge of the relevant art are within the scope of the present invention. It is intended that the appended claims be construed to include all alternative embodiments as permitted by the prior art.